The design, construction and commissioning of a Bench Scale Hydrogenation Unit

FINAL REPORT

BY

Stearns Catalytic Ltd., Sarnia, Ontario

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada.

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MICROMEDIA

LIST OF CONTENTS

Page 2	-	Summary
Page 3	-	Introduction - Scope of Work
Pages 4 to 11	-	Technical Discussion
4 to 6	-	Functional Design Requirements
7 to 9	-	System Design Description
9	-	Construction
10	-	Testing
10	-	Commissioning
11	-	Recommendations
Page 11	-	Design Data

APPENDIX

Balance Flow Diagram, Drawing B-00200A, Rev. 0

Balance Data, Drawing B-00200B, Rev. 2

Electrical 230 Volt Single Line, Drawing D-16000, Rev. 1

Master Equipment List, Sheets 1 and 2

Plan of Work and Cost (Appendix E)

SUMMARY

The project of the design, procurement, construction and commissioning of a bench scale hydrogenation unit by Stearns Catalytic Ltd. of Sarnia, Ontario was successfully completed within budget and handed over to Energy, Mines and Resources, Canada in September 1983.

The design was developed by Stearns Catalytic Ltd. from a basic Process Flow Diagram originating from the Coal Liquefaction Department of Energy, Mines and Resources, CANMET Research Laboratories.

Equipment selection and instrumentation design described under sections 1 and 2 of the technical discussion was continuously reviewed with Energy, Mines and Resources, as was the construction phase.

The skid mounted unit type construction facilitated shipment and retained the integrity of all pre-shipment testing.

Commissioning at the CANMET establishment was closely monitored by CANMET personnel.

The final cost of the project broken down into main activities is shown in the "Plan of Work and Cost" sheet, Appendix E.

INTRODUCTION

Scope of Work

The design, procurement, construction and commissioning of a bench scale continuous hydrogenation unit for upgrading coal derived synthetic crudes and for hydrogenation of recycle solvents.

The construction to be of modular approach to provide versatility in equipment design and layout.

All methods, equipment and techniques used to meet standards followed in the design and construction of petroleum processing equipment where practicable.

The system is required to achieve the following operating conditions:

1. Reactor temperature : up to 1000°F
2. Reactor pressure : up to 5000 p.s.i.
3. Liquid feeding rates : up to 1 G.P.H.
4. Gas feeding rates : up to 200 SCFH
5. Reaction gases : hydrogen and synthesis gas
6. Reaction liquids : coal-oil slurries and heavy hydrocarbons

The design of the hydrogenation unit to include the following capabilities:

1. Automatic gas feed.
2. Automatic slurry/liquid feed
3. Two reactor vessels
4. High-pressure, high-temperature product separators
5. Automatic product-pressure let-down (slurry phase)
6. Automatic temperature and pressure controls
7. Automatic gas pressure let-down including gas clean-up train.

TECHNICAL DISCUSSION

The discussion is broken down into six specific sections.

1. Functional Design Requirements
2. System Design Description
3. Construction
4. Testing
5. Commissioning
6. Recommendation

1. Functional Design Requirements

1.1.1 Process

The pilot plant is designed to take a refined coal slurry as the primary liquid feed and hydrogen and carbon monoxide as the gas feed. The feeds are preheated to 350°F and combined to enter the first Reactor at a pressure range of 1000 to 5000 psig. The hydrogenated products exiting from the second Reactor at 850°F, nominal, are pre-cooled to approximately 400°F before being phase-separated in the Hot Separator.

The liquid fractions are continuously flashed down to the low pressure system operating at atmospheric pressure.

The gaseous products, exiting at the top of the Hot Separator, are subsequently let-down to atmospheric pressure, after being dried and the scrubbing out of sulphur compounds.

Feed sampling, products sampling and volumetric flow measurements are provided. These, together with the mass flow measurement of the feed gas and slurry feed weighing will enable a reasonable account for mass balance, kinetics and other parametric variations.

1.1.2 Material Balance

The steady operating pressures and temperatures of the key process streams are indicated in the Balance Flow Diagram, Drawing B-00200A. The balance data is tabulated on Drawing B-00200B.

Being a pilot plant, the operating parameters and hence, the product slate from a given feed composition could vary considerably. The data shown in the reference drawings is based on basic data provided by Energy, Mines and Resources, CANMET Research Laboratories.

1. Functional Design Requirements (continued)

1.2.1 Instrumentation and Control

Measurement, control, indicating and recording instrumentation is partly electronic and partly pneumatic.

The selections of manufacture was influenced in many cases, by the "free issue" of certain items provided by Energy, Mines and Resources, CANMET Research Laboratories, in the interest of standardization and spare parts inventories.

The requirement for Pneumatic versus Electronic instrument selection was dictated by CANMET in the early design stages of the unit.

The location of temperature and pressure controlling, recording and indicating sensors, was made for maximum flexibility for optimum control, measurement and information of unit function. For example, three thermocouples are contained in a one eighth diameter sheath and inserted into each of the two Reactors and the Hot Separator such that the internal temperature of the Top, Middle and Bottom zones can be reached. This allows optimum setting of the heater controls, the sensors of which are located on the outside skin of the Vessel, thereby minimizing the possibility of coking problems.

A dual gas feed measurement and control system for both the hydrogen and carbon monoxide was designed for rangeability reasons, brought about by the required minimum to maximum ranges of gas flow required to obtain maximum accuracy. Likewise a dual system was built, to enable switching and changing of filter elements in the event of a high differential pressure indication across the filters upstream of the high pressure gas let-down to the caustic scrubber.

Exhaustive inquiries were ma[redacted]or the most accurate, reliable and repeatable level measurement for the Hot Separator level control; these included weight measurement, sonic probes and nuclear devices. The elimination of unwanted friction and hysteresis effects due to piping connections and temperature limitations of sensors made the nuclear device the best choice. The nuclear transmitter signal is sent to a panel mounted controller, the output of which, being transduced to a pneumatic signal and routed through a selector switch, controls either of a dual system of let-down valves to control the Separator level.

Three free standing control panels house all of the required instrumentation for control, record or alarm purposes. One panel houses electronic and pneumatic controllers and indicators, another houses the Alarm Annunciator system together with the heater controllers and multipoint temperature recorder, while the third, houses the pump variable speed controls and the electronic part of an automatic multi-sample collecting system for analysis of gas samples.

1. Functional Design Requirements (continued)

1.3.1 Mechanical and Piping

The mechanical items as listed in the Master Equipment List (see appendix) and shown on the Piping and Instrument Diagram Drawing E-00201, Revision 7 (in the custody of CANMET Research Laboratories), consists generally of high pressure and low pressure stainless steel vessels.

Two variable feed slurry pumps described within Section 2; High Pressure stainless steel tubing with "Autoclave" type high pressure fittings.

1.4.1 Operation, Maintenance and Safety

The unit is designed to be operated by a single operator. Most functions of control during operation such as motor speed control, equipment temperature controls, level control, temperature and weight recording, etc., is performed from a free standing local control panel.

The setting of gas feed rates, slurry feed tank heating, filling and pumping rates, thermostat setting for heat tracing of tubing and selection of cooling agent, is necessary prior to the commencement of a run. If radical changes are made to the pressures and flow rates of subsequent runs, some fine tuning adjustments to control instruments and sample taking are the only function that should be necessary on the unit.

The unit is designed to minimize maintenance. The selection of "Autoclave" type connections enables connections to be readily broken and reassembled. Layout is designed for vessel cleaning accessibility.

Safety was of paramount importance in the design, to this end construction materials such as vessels and tubing were purposely selected of a much higher pressure and temperature rating than required. All systems are equipped with pressure relief valves and/or rupture discs. High pressure and high temperature alarms are built into the unit. At completion of construction the unit was subjected to a hydrostatic test of 1½ times the design pressure.

All electrical equipment where practicable met or exceeded area classification.

As a final safety measure, a half inch thick clear "Lexan" panel screening was provided to fully enclose the unit.

2. System Design Description

2.1.1 Slurry and Gases Feed

Coal slurry feed is prepared externally, preheated, manually loaded into the Slurry Feed Tank for each operational run. Maximum batch size is 5 gallons, the nominal tank capacity.

The feed tank is equipped with an air operated variable speed stirrer and connections for nitrogen blanketing and excess slurry flow return. Splashing dampening on the return is obtained by an extended tube inside the tank.

A tank heater is installed circumferentially for bringing the slurry temperature up to 300 - 350°F, the pre-hydrogenation temperature. The tank and its ancillary equipment and tubing is seated on a sensitive weigh scale.

The Slurry Circulation Pump is capable of pumping approximately 20 GPH at 50 psig discharge pressure, this flow is higher than the required feed rate the excess being discharged back to the feed tank and controlled with a manually operated valve.

The heated slurry, roughly 1 GPH at 300°F is then fed to a Piston Pump which pressurizes the feed up to a maximum of 5000 psig, dependant on the stroke and speed adjustment. This Piston Pump is fitted with four heads, 2 x 4 mm and 2 x 6 mm. Solvent flushing and de-plugging facility is provided from one dedicated 6 mm head connected to an adjacent Solvent Feed Tank and Solvent Return Drum.

High pressure feed gases, hydrogen and carbon monoxide are pre-filtered and pressure regulated to a desired operating pressure. Mass flow meters are installed for each gas flow system. The combined gases are mixed and preheated in an accumulator enclosed in a heater oven.

It should be noted that the CANMET supplied Tylon mass flow meters have a maximum allowable operating pressure of 3000 psig, as such the unit has a restriction of maximum operating pressure of 3000 psig until such time as these meters are replaced by a 5000 psig rated meter.

A gas sampling connection is provided downstream of the accumulator prior to a check valve and junction with the slurry feed line.

2.1.2 Reactors

The mixture of coal slurry and feed gases is channelled through two Reactors in series, both reactors are enclosed in three zone heaters capable of raising the pre-reaction temperature of 300°F to 1200°F. Each reactor has an internal three zone temperature element connected to a recorder.

2. System Design Description

2.1.2 Reactors (continued)

Emerging from the top of the second Reactor the products are cooled in the Product Coolers to around 400°F, these two coolers take either cooling water or air as the cooling medium, adjusted as necessary.

The cooled reactor products are separated in a Hot Separator vessel. The gas/vapour components emerging at the top and the liquid/condensed phase is continuously flashed down via a let-down valve to the atmospheric low pressure system. The control of the level within the Hot Separator is by means of nuclear level detector.

2.1.3 High Pressure System

High pressure gases are cooled to approximately 70°F in a condenser, the resulting condensed components are collected in a sample receptacle and subsequently valved to a high pressure sample collection/analysis receiver. The remaining non-condensed gases are scrubbed of sulphur compounds, dried and let-down to atmospheric pressure through a control valve.

Caustic gases are then removed in a final scrubber before a volumetric gas meter for flow measurement. A gas sampling connection is located downstream of the meter.

A separate meter using nitrogen is supplied for calibration purposes of both the high and low pressure gas flow meters.

2.1.4 Low Pressure System

The vapour-liquid products flashed down from the Hot Separator are received in a Sample Pot or the L.P. Receiver. The liquid portion is collected and the vapour components enter an L.P. Condenser and Sampling Receptacle for valving off and analysis. The remaining non-condensed gases are vented to a gas flow meter, again sampling can be done similar to the H.P. gas system.

Before a steady state operating condition is achieved, the L.P. system can be purged of the stagnant or trapped air by using the product gases by means of two four-way valves. The valving position being changed from purging to sampling, when the desired steady state has been reached.

2.1.5 Utilities and Peripheral Support

A pressure regulated nitrogen service is provided for nitrogen blanketing of the slurry feed tank, purging of the low pressure gas system and calibration of the gas flow meters.

2. System Design Description

2.1.5 Utilities and Peripheral Support (continued)

Instrument air service is cleaned in a cartridge type filter then further cleaned by individual filters at each air consuming instrument.

The 220 volt single phase electrical supply is fed to the main control panel where it is split to separate panels for main power and heat tracing. Each sub feed has individual fuse protection.

All safety relief valves and rupture discs are piped into a closed ventilation header system for venting to the outside of the building.

A carbon monoxide detector and alarm system is incorporated into the building safety protection system.

3. Construction

The limitations on available space at the CANMET facility resulted in a very compact layout, initially intended as a two section frame. The final construction was achieved on a one piece frame work of overall dimension some 17 feet long by 6 feet 6 inches wide by 8'-0" high, the two pumps were mounted on separate base frames for ease of handling and to eliminate vibration.

Much of the selected components and instrumentation is of critical design and considerable research was carried out to obtain satisfactory items, often from a very restricted suppliers list.

The construction was carried out in a section of a Sarnia custom machine shop, custom machining, fabrication, equipment mounting and some tube assembly was subcontracted. Subcontract labour was at all times fully supervised by our own work force. All instrument installation, instrument and electrical wiring and control panel construction was carried out by our own labour.

Custom machining and adaptation was resorted to and the low pressure sampling system is one example of a unique design.

The work was reviewed at set times during construction by CANMET personnel to ensure acceptability of layout and quality of workmanship.

No major difficulties were encountered during construction, the facilities of an excellent machine shop proved essential, and the added advantage of specialist consumable suppliers in the Sarnia area aided in eliminating delays for any urgently required items.

4. Testing

Instrumentation received prior to construction commencement, was where possible, checked and tested. Thereafter, items were installed as received and again where possible, tested during construction.

At completion of construction a punch-out was carried out against the Piping and Instrument Diagram. The unit was subjected to a hydrostatic test of 1½ times the design pressures.

All instrumentation was checked, calibrated and tested with the exception of the Hot Separator nuclear level detector, this was scheduled to be carried out by the supplier when the unit was installed in Ottawa.

All electrical circuits were checked, pump motors run and heaters checked.

More than to be expected problems were experienced with malfunctioning instruments, all of which required expeditious replacement or repair under vendors warrantee.

5. Commissioning

Prior to commissioning at the CANMET laboratories some pre-commissioning work was done in Sarnia in conjunction with the testing phase.

Commissioning of a research pilot plant in itself is not expected to be an easy, problem free task. Apart from the normal instrument adjustments and re-calibrations only two significant problem items were encountered, previous detailed design and research of available equipment and instrumentation prior to selection probably minimized potential problems.

The previously checked, tested and calibrated Tylon mass flow meters failed to record accurately, this was ultimately found to be caused by an oil contamination in the CANMET hydrogen supply, though slight, sufficient to affect the instrument. The problem was rectified by installing an activated carbon filter system to clean up the hydrogen supply to the unit.

The second item concerned valve trim in the Hot Separator liquid let-down valves, microscopic changes were made to the valve trim design, changing slightly the C.V. value and stabilizing the level within the Hot Separator.

At the finalization of this contract a successful steady run was achieved using a coal-oil slurry feed.

6. Recommendations

Few if any recommendations can be offered with respect to any process modifications or future additions for feed flexibility and experimentability.

This will evolve from experiment and experience with the operation of the unit by CANMET Research Laboratories.

Construction techniques used should allow for adaptability and the expansion of the control panel.

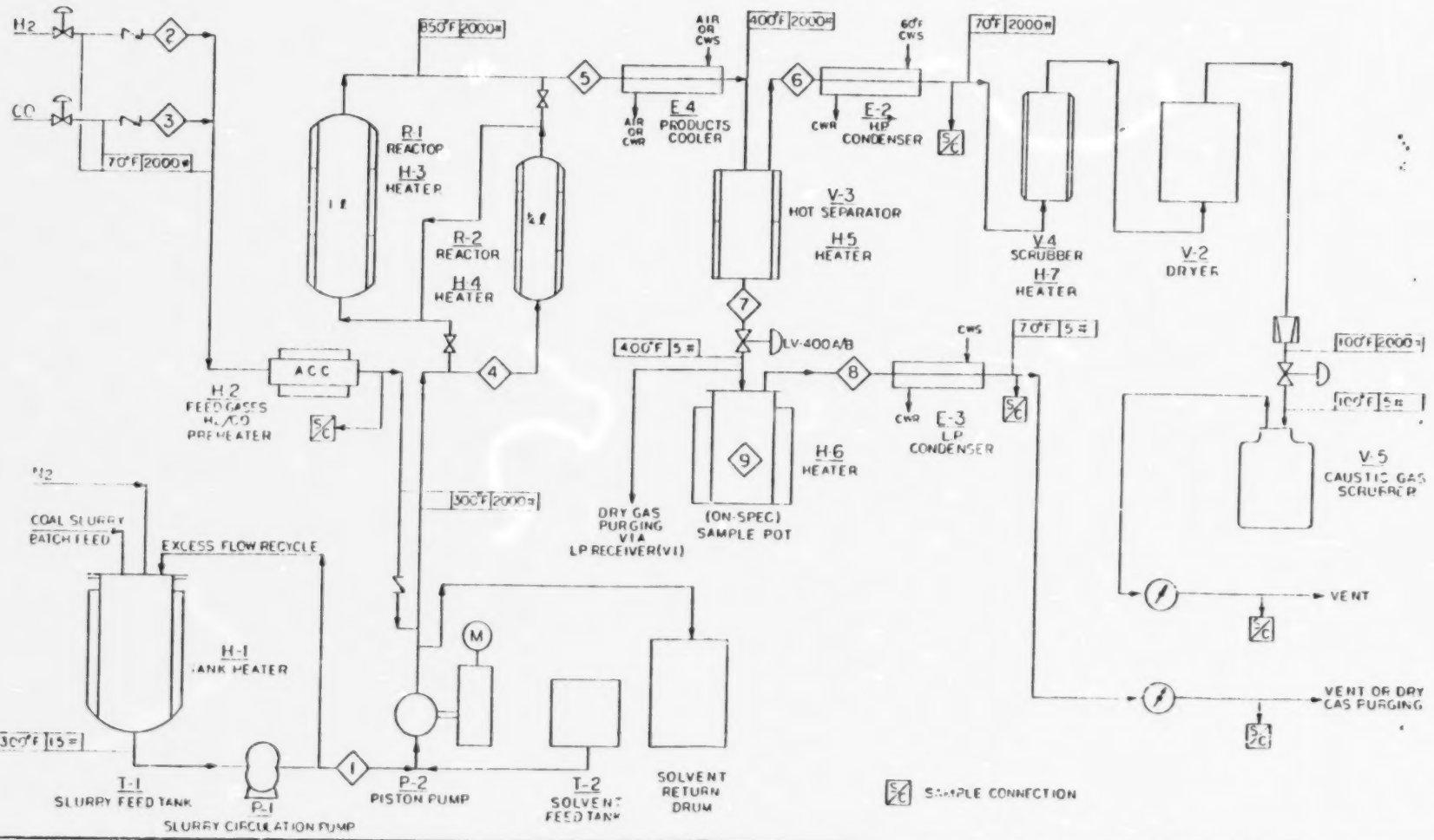
Recommendations for similar type projects would suggest in depth research on experience with similar plants, detailed investigation on available equipment and instrumentation, availability of workshop facility with precision machining/welding capability.

DESIGN DATA

At the completion of the contract one complete set of Engineering Data Books in three volumes was supplied to CANMET Research Laboratories. These books include all process, instrument, electrical and mechanical design data together with instrumentation loop diagrams and specification sheets, instrument and equipment manufacturers operation and maintenance manuals.

A complete set of Purchase orders together with a purchase order log was also included.

Report prepared by:
V.G. Rayfield
Project Manager
Stearns Catalytic Ltd.
Date: December 2, 1983



ENERGY, MINES & RESOURCES CANADA	KL
BALANCE FLOW DIAGRAM COAL	DRWN
HYDROGENATION EQUIPMENT	NONE
Catalytic	E-C021-C4

	STREAM No. / STREAM DESCRIPTION	① † COAL SLURRY FEED	② † HYDROGEN FEED	③ † CARBON MONOXIDE FEED	④ † REACTOR FEED	⑤ * REACTOR PRODUCTS	⑥ * H.P. GASES	⑦ * H.P. LIQUID	⑧ * L.P. GASES	⑨ * L.P. LIQUID	◇
1	TOTAL STREAM MOLS/HR										
2	USE CONDITION	Slurry	Gas	Gas	Slurry/Gas	Gas/Liq/Solid	Gas	Liquid	Gas	Liquid	
3	LB/HR	6,614	.365	5.077	12.06	12.06	2.88	9.18	0.49	8.69	
4	PRESSURE, PSIA	60	3,015	3,015	3,015	2,000	2,000	2,000	20	20	
5	TEMPERATURE, °F.	300	70	70	300	840	400	400	400	400	
6	ENTHALPY, MMBTU/HR										
7	ACFM										
8											
9	VAPOUR PHASE MOLS/HR		.181	.181	.362						
10	LB/HR		.365	5.077	5.44		2.88		0.49		
11	SCFM		1.084	1.084	2.167						
12	M. WT		2	28	15				35.9		
13	(2) BTU/LB										
14	MMBTU/HR										
15	COMP. FACTOR, Z		1.18	1.0	1.088						
16	(3) LB/FT^3 (T,P)		0.91	14.84	5.092						
17	(3) VISCOSITY (T,P) CP		.009	.018	.0227						
18	ACFM		.401	.342	1.0680						
19											
20											
21	LIQUID PHASE MOLS/HR										
22	LBS/HR	6.614			6.614			9.18		8.69	
23	BPSD										
24	UOP "K"										
25	MOL WT										
26	(2) BTU/LB										
27	MMBTU/HR										
28	SP. GR. @ 60°F										
29	°API	10			10						
30	(3) LB/FT^3 (T,P)	62.4			62.4			60		60	
31	(3) VISCOSITY (T,P) CP	2.0			2.0						
32	(3) USGPM (T,P)	1			1			1.5		1.4	
33											
34											
35	LIQ PHASE FREE WATER, LB/HR										
36	LIQ PHASE FREE WATER, MMBTU/HR										

NOTES
(1) STD ATMOS PRESS 14.7 PSIA
(2) BASIS (VAP) or (LIQ) at ____ °F
(3) (T,P) REFERS TO FLOWING CONDITIONS

*Mass balance data from ⑤ on
Based on M. IKURA's letter to V Rayfield dated Jan. 25, 1983

† Data from ① to ④
Based on normal maximum Operating Feed conditions

NO.	DESCRIPTION	BY	APP'D	DATE
2	REVISED TO INCLUDE ⑤ & ⑦	PJD		[illegible] '83
1	APPROVED FOR CONSTRUCTION	GM	BS	23/11/'82

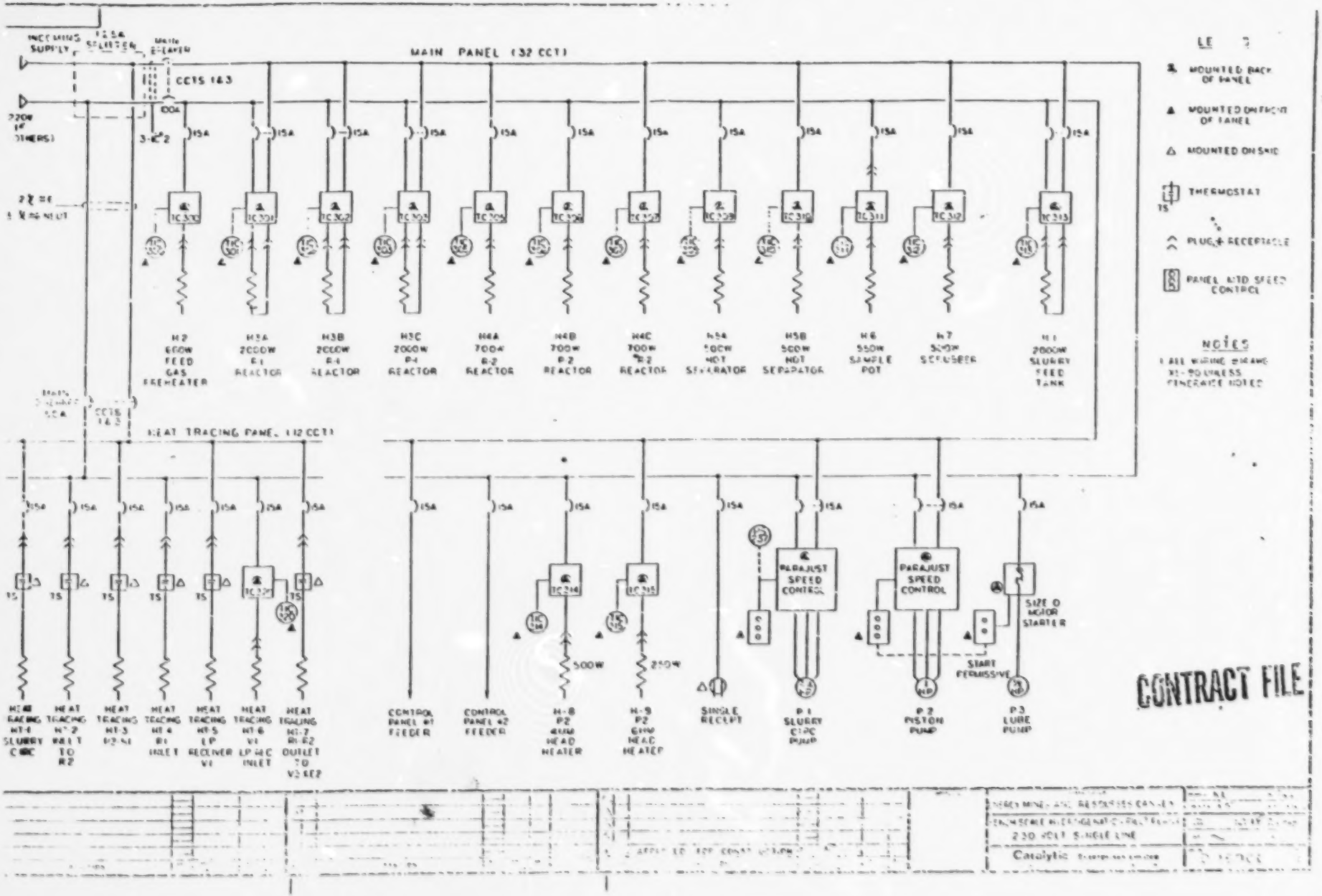
PREPARED FOR
ENERGY, MINES & RESOURCES CANADA

STREAM PROPERTIES

Catalytic Enterprises Limited
CALGARY

DRAWN BY GM		DATE 22/10/82
CHECKED BY FHW		DATE 05/07/83
ENG. FHW	SUPV. GM	APP'D
VGR	EMR	2372

JOB NO. B-00200B



CONTRACT FILE

C. Ltd. 256 Rev. 3

CATALYTIC ENTERPRISES LIMITED

MASTER EQUIPMENT LIST

ITEM NO.	TITLE & DESCRIPTION		P.O. No. DATE	REMARKS
R.1	REACTOR (cap 1L)		1 11 NOV 80	
R.2	REACTOR (cap 1/4 1)			C.S.
E.2	H.P. CONDENSER		———	FABRICATED BY CATALYTIC
E.3	L.P. CONDENSER		———	FABRICATED BY CATALYTIC
E.4 A/B	PRODUCTS COOLERS		———	FABRICATED BY CATALYTIC
H.1	SLURRY FEED TANK HEATER		48 SUPP #1 23 MAR 83	
H.2	FEED GAS PREHEATER		48 11 FEB 83	
H.3	REACTOR R.1 HEATER		27 11 MAY 81	
H.4	REACTOR R.2 HEATER			C.S.
H.5	HOT SEPARATOR HEATER		48 SUPP #1 23 MAR 83	
H.6	SAMPLE POT HEATER		53 3 MAR 83	
H.7	SCRUBBER V-4 HEATER		48 SUPP #1 23 MAR 83	
V.1	L.P. RECEIVER			C.S.
V.2	DRYER		1 SUPP #1 22 DEC 80	
V.3	HOT SEPARATOR			C.S.
V.4	SCRUBBER		1 SUPP #1 22 DEC 80	
V.5	CAUSTIC GAS SCRUBBER		53 3 MAR 83	
		(C.S. DENOTES CLIENT SUPPLY)		

CONTRACT NO 2372	PREP. V.G.R.	SHEET 1 OF 2	DWG. NO.	REV.	NO. 2
COMPANY E.M.R.	APPR.				DATE 18 MAY 83

C. Ltd. 256 Rev. 3

CATALYTIC ENTERPRISES LIMITED

MASTER EQUIPMENT LIST

ITEM NO.	TITLE & DESCRIPTION		P.O. No. DATE	REMARKS
T.1	SLURRY FEED TANK (5 GAL.)		_____	FABRICATED BY CATALYTIC
T.2	SOLVENT FEED TANK (5 GAL.)		45 15 FEB 83	
P.1	SLURRY CIRCULATION PUMP C/W MOTOR		23 16 FEB 81	
P.2	VARIABLE SPEED PISTON PUMP C/W MOTOR		25 1 APR 81	C.S. MODS. S.C.I.
P.3	PISTON PUMP LUBE OIL PUMP		25 1 APR 81	
F.1 A/B	FILTERS DRY GAS		6 23 DEC 80	
F.2 A/B	FILTERS DRY GAS		6 23 DEC 80	
F.3	H_2 INLET FILTER		6 SUPP #1 27 FEB 81	
F.4	CO INLET FILTER		6 SUPP #1 27 FEB 81	
F.5	GAS MIXING FILTER		6 23 DEC 80	
S.1	SLURRY FEED TANK SCALE		29 16 FEB 83	
AG-1	SLURRY FEED TANK MIXER		50 16 MAR 83	
S.C.1	P.1 PUMP SPEED CONTROLLER		23 16 FEB 81	
S.C.2	P.2 PUMP SPEED CONTROLLER		51 8 MAR 83	

CONTRACT NO. 2372	PREP. V.G.R.	SHEET 2 OF 2	DWG. NO.	REV.	NO. 2
COMPANY E.M.R.	APPR.				DATE 18 MAY 83

STEARNS CATALYTIC JOB No. 2372

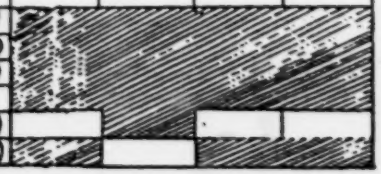
CUST PROJECT NO. OSQ80-00095
REQUISITION NO. 23440-9-9160
DATE 30 NOV '83 REVISION NO. 5

PLAN OF WORK AND COST (APPENDIX E)
CONTRACTOR: STEARNS CATALYTIC LTD.
TITLE: BENCH SCALE HYDROGENATION UNIT

CONCURRED BY (INITIALS):
CONTRACTOR: MJR
GOV'T: _____ SSC: _____

	% COMPLETE	WORK BREAKDOWN (ACTIVITIES/MILESTONES) MONTHS		1 1982 DEC	2 1983 JAN	3 FEB	4 MARCH	5 APRIL	6 MAY	7 JUNE	8 JULY	9 AUG	10 SEPT	11 OCT	12 NOV	EST COST ACTIVITY/ MILESTONE	FOR CONT USE ONLY	FINANCIAL SUMMARY IN ACTIVITIES/MILESTONES: Forecast To Date	Actual To Date	Est. To Completion	Variation
Planned Actual Expenditure	100	TASK 1. DETAILED DESIGN & SPECS	P		— — —	— — —	— — —	— — —	— — —							58			53	0	−5
			A/E		— — —	— — —	— — —	— — —													
	100	TASK 2. EQUIP. PURCHASE	P		— — —	— — —	— — —	— — —	— — —	— — —						17			19	0	+2
			A/E		— — —	— — —	— — —	— — —	— — —	— — —											
	100	TASK 3. CONSTRUCTION SUPERVISION	P		— — —	— — —	— — —	— — —	— — —	— — —	— — —						36			45	0	+9
			A/E		— — —	— — —	— — —	— — —	— — —	— — —	— — —										
	100	TASK 4. SUB-CONTRACT AND CONSTRUCTION	P		— — —	— — —	— — —	— — —	— — —	— — —	— — —						50			72	0	+22
			A/E		— — —	— — —	— — —	— — —	— — —	— — —	— — —										
	100	TASK 5. COMMISSIONING	P							—	— — —	— — —	— — —			25			31	0	+6
			A/E							—	— — —	— — —	— — —								
	96	SUPERVISION, ADMIN. EX.	P		— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —			39			26	1	−12
			A/E		— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —							
	100	DIRECT CHARGES, TRAVEL ETC	P													27			20	0	−7
			A/E																		
	100	MATERIAL & EQUIP. COSTS	P													255			222	0	−33
			A/E																		
	100	PANEL CONSTRUCTION	P				— — —	— — —	— — —	— — —									14	0	+14
			A/E				— — —	— — —	— — —	— — —											
			P											TOTALS		507*			502	1	−4
			A/E																		
Work Performance Activities Milestones		MAJOR EQUIPMENT SPECIFIED & DESIGNED	P				△														
			A/E				△														
		MAJOR PURCHASE ORDERS PLACED	P					△													
			A/E					△													
		CONSTRUCTION COMPLETED	P							▽	△										
			A/E					▽			△										
		PILOT PLANT DELIVERED	P								▽					DEC					
			A/E								▽										
		COMMISSIONING AND FINAL REPORT	P									△	▽								
			A/E									△	▽								
LABOUR	PERSON DAYS - PLANNED		P		20	71	62	52	46	30	40	51	5				(377)				
	- ACTUAL & EXPECTED		A/E		20	70	61	61	76	78	55	12	19	7	2	4	(465)				
EXPS	BY MONTH - PLANNED		P		8	32	37	53	55	41	38	26	1				(241)				
	- ACTUAL & EXPECTED		A/E	216	8	44	47	31	46	40	34	11	20	2	3	1					
	CUMULATIVE - PLANNED		P		224	256	293	346	401	442	480	506	507				(507)				
	- ACTUAL & EXPECTED		A/E	216	224	268	315	346	392	432	466	477	497	499	502	503	(503)				

REPORTING AS OF (MARK ▲ UNDER APPLICABLE MONTH)



OSQ80-00095

NOTE: EXPENDITURE ACTUAL INCLUDES COSTS OF MATERIALS COMMITTED BY ISSUED PURCHASE ORDERS.

REV. 3. JAN 1983. INCLUDES CONTRACT AMENDMENT DATED JAN 7, 1983
REV. 4. FEB 1983 PANEL CONSTRUCTION ISOLATED
REV. 5. APRIL 1983 TASK 4. REVISED TO 'SUB-CONTRACT AND CONSTRUCTION'